

CLAIMS

What is claimed is:

- 1 1. A method for generating a speech recognition database comprising:
 - 2 generating a latent semantic analysis (LSA) space from a training corpus of
 - 3 documents representative of a language;
 - 4 receiving a new document that represents a change in the language; and
 - 5 adapting the LSA space to reflect the change in the language.

- 1 2. The method of claim 1, wherein adapting the LSA space to reflect the change in
- 2 the language comprises transforming the LSA space to take into account the new
- 3 document's influence on the LSA space without re-computing the LSA space.

- 1 3. The method of claim 1, wherein transforming the LSA space comprises:
 - 2 obtaining a training document vector that characterizes a semantic position of the
 - 3 training document within the LSA space;
 - 4 computing a new document vector that characterizes a semantic position of the
 - 5 new document within the LSA space;
 - 6 deriving a document vector transformation matrix; and
 - 7 applying the document vector transformation matrix to the training document
 - 8 vector and the new document vector to shift a position of each document vector in the
 - 9 LSA space, where the shift in the position reflects the change in the language.

1 4. The method of claim 3, further comprising:
2 obtaining a training word vector that characterizes a semantic position of the
3 training word within the LSA space;
4 computing a new word vector that characterizes a semantic position of the new
5 word within the LSA space;
6 deriving a word vector transformation matrix; and
7 applying the word vector transformation matrix to the training word vector and
8 the new word vector to shift a position of each word vector in the LSA space, where the
9 shift in the position reflects the change in the language.

1 5. The method of claim 4, wherein:
2 the training document vector is VS , where VS is computed from a right singular
3 matrix V and a diagonal matrix S , each of which was obtained from a previous singular
4 value decomposition (SVD) of a training word-document matrix constructed during the
5 generation of the LSA space, the training word-document matrix representing the extent
6 to which each of the words appears in each of the documents of the training corpus;
7 the new document vector ZS , where ZS is computed from the diagonal matrix S
8 and an extension matrix Z , wherein Z is an extension of the right singular matrix
9 V obtained by folding in a new word-document matrix, the new word-document matrix
10 representing the extent to which a new word appears in the new document; and
11 the document vector transformation matrix is J , wherein J is obtained from a
12 Choleski decomposition of a matrix derived from an extension matrix Y , wherein Y is an

13 extension of a left singular matrix U obtained by folding in the new word-document
14 matrix, and wherein U was obtained from the previous SVD of the training word-
15 document matrix constructed during the generation of the LSA space.

1 6. The method of claim 5, wherein:

2 the training word vector is US , wherein US is computed from the left singular

3 matrix U and the diagonal matrix S ;

4 the new word vector is YS , wherein YS is computed from the diagonal matrix S

5 and the extension matrix Y ; and

6 the word vector transformation matrix is K , wherein K is obtained from a

7 Choleski decomposition of a matrix derived from the extension matrix Z .

1 7. The method of claim 6, wherein transforming the LSA space comprises applying
2 the document vector transformation matrix and the word vector transformation matrix
3 simultaneously.

1 8. The method of claim 6, wherein when the new document matrix contains more

2 new documents than new words, then transforming the LSA space comprises:

3 applying the word vector transformation matrix K , first; and

4 applying the document vector transformation matrix J second, wherein the

5 extension matrix Y is not obtained by folding in the new word-document matrix, but is

6 rather derived from the extension matrix Z .

1 9. The method of claim 6, wherein when the new document matrix contains more
2 new words than new documents, then transforming the LSA space comprises:
3 applying the document vector transformation matrix J first; and
4 applying the word vector transformation matrix K second, wherein the extension
5 matrix Z is not obtained by folding in the new word-document matrix, but is rather
6 derived from the extension matrix Y .

1 10. The method of claim 1, wherein the change in the language is a change in the
2 language's domain.

1 11. The method of claim 1, wherein the change in the language is a change in the
2 language's style.

1 12. A computer-readable medium having executable instructions to cause a computer
2 to perform a method for generating a speech recognition database comprising:
3 generating a latent semantic analysis (LSA) space from a training corpus of
4 documents representative of a language;
5 receiving a new document that represents a change in the language; and
6 adapting the LSA space to reflect the change in the language.

1 13. The computer-readable medium of claim 12, wherein adapting the LSA space to
2 reflect the change in the language further comprises transforming the LSA space to take

3 into account the new document's influence on the LSA space without re-computing the
4 LSA space.

1 14. The computer-readable medium of claim 13, wherein transforming the LSA space
2 further comprises:

3 obtaining a training document vector that characterizes a semantic position of the
4 training document within the LSA space;

5 computing a new document vector that characterizes a semantic position of the
6 new document within the LSA space;

7 deriving a document vector transformation matrix; and

8 applying the document vector transformation matrix to the training document
9 vector and the new document vector to shift a position of each document vector in the
10 LSA space, where the shift in the position reflects the change in the language.

1 15. The computer-readable medium of claim 14, wherein transforming the LSA space
2 further comprises:

3 obtaining a training word vector that characterizes a semantic position of the
4 training word within the LSA space;

5 computing a new word vector that characterizes a semantic position of the new
6 word within the LSA space;

7 deriving a word vector transformation matrix; and

8 applying the word vector transformation matrix to the training word vector and
9 the new word vector to shift a position of each word vector in the LSA space, where the
10 shift in the position reflects the change in the language.

1 16. The computer-readable medium of claim 14, wherein:
2 the training document vector is VS where VS is computed from a right singular
3 matrix V and a diagonal matrix S , each of which was obtained from a previous singular
4 value decomposition (SVD) of a training word-document matrix constructed during the
5 generation of the LSA space, the training word-document matrix representing the extent
6 to which each of the words appears in each of the documents of the training corpus;
7 the new document vector is ZS where ZS is computed from the diagonal matrix
8 S and an extension matrix Z , wherein Z is an extension of the right singular matrix
9 V obtained by folding in a new word-document matrix, the new word-document matrix
10 representing the extent to which a new word appears in the new document; and
11 the document vector transformation matrix is J , wherein J is obtained from a
12 Choleski decomposition of a matrix derived from an extension matrix Y , wherein Y is an
13 extension of a left singular matrix U obtained by folding in the new word-document
14 matrix, and wherein U was obtained from the previous SVD of the training word-
15 document matrix constructed during the generation of the LSA space.

1 17. The computer-readable medium of claim 16, wherein:

2 the training word vector is US , wherein US is computed from the left singular
3 matrix U and the diagonal matrix S ;
4 the new word vector is YS , wherein YS is computed from the diagonal matrix S
5 and the extension matrix Y ; and
6 the word vector transformation matrix is K , wherein K is obtained from a
7 Choleski decomposition of a matrix derived from the extension matrix Z .

1 18. The computer-readable medium of claim 17, wherein transforming the LSA space
2 further comprises applying the document vector transformation matrix and the word
3 vector transformation matrix simultaneously.

1 19. The computer-readable medium of claim 17, wherein, when the new document
2 matrix contains more new documents than new words, transforming the LSA space
3 further comprises:

4 applying the word vector transformation matrix K , first; and
5 applying the document vector transformation matrix is J second, wherein the
6 extension matrix Y is not obtained by folding in the new word-document matrix, but is
7 rather derived from the extension matrix Z .

1 20. The computer-readable medium of claim 17, wherein, when the new document
2 matrix contains more new words than new documents, transforming the LSA space
3 comprises:

4 applying the document vector transformation matrix J first; and
5 applying the word vector transformation matrix K second, wherein the extension
6 matrix Z is not obtained by folding in the new word-document matrix, but is rather
7 derived from the extension matrix Y .

1 21. The computer-readable medium of claim 12, wherein the change in the language
2 is a change in the language's domain.

1 22. The computer-readable medium of claim 12, wherein the change in the language
2 is a change in the language's style.

1 23. An apparatus for generating a speech recognition database, the apparatus
2 comprising:
3 a latent semantic analysis (LSA) space generator to generate an LSA space from a
4 training corpus of documents representative of a language;
5 a document receiver to receive a new document that represents a change in the
6 language; and
7 an LSA space adapter to adapt the LSA space to reflect the change in the
8 language.

1 24. The apparatus of claim 23, wherein LSA space adapter transforms the LSA space
2 to take into account the new document's influence on the LSA space without re-
3 computing the LSA space.

1 25. The apparatus of claim 23, wherein the LSA space adapter transforms the LSA
2 space by:

3 obtaining a training document vector that characterizes a semantic position of the
4 training document within the LSA space;

5 computing a new document vector that characterizes a semantic position of the
6 new document within the LSA space;

7 deriving a document vector transformation matrix; and

8 applying the document vector transformation matrix to the training document
9 vector and the new document vector to shift a position of each document vector in the
10 LSA space, where the shift in the position reflects the change in the language.

1 26. The apparatus of claim 25, wherein the LSA space adapter further transforms the
2 LSA space by:

3 obtaining a training word vector that characterizes a semantic position of the
4 training word within the LSA space;

5 computing a new word vector that characterizes a semantic position of the new
6 word within the LSA space;

7 deriving a word vector transformation matrix; and

8 applying the word vector transformation matrix to the training word vector and
9 the new word vector to shift a position of each word vector in the LSA space, where the
10 shift in the position reflects the change in the language.

1 27. The apparatus of claim 26, wherein:
2 the training document vector is VS , where VS is computed from a right singular
3 matrix V and a diagonal matrix S , each of which was obtained from a previous singular
4 value decomposition (SVD) of a training word-document matrix constructed during the
5 generation of the LSA space, the training word-document matrix representing the extent
6 to which each of the words appears in each of the documents of the training corpus;
7 the new document vector ZS , where ZS is computed from the diagonal matrix S
8 and an extension matrix Z , wherein Z is an extension of the right singular matrix
9 V obtained by folding in a new word-document matrix, the new word-document matrix
10 representing the extent to which a new word appears in the new document; and
11 the document vector transformation matrix is J , wherein J is obtained from a
12 Choleski decomposition of a matrix derived from an extension matrix Y , wherein Y is an
13 extension of a left singular matrix U obtained by folding in the new word-document
14 matrix, and wherein U was obtained from the previous SVD of the training word-
15 document matrix constructed during the generation of the LSA space.

1 28. The apparatus of claim 26, wherein:

2 the training word vector is US , where US is computed from a left singular matrix
3 U and the diagonal matrix S ;
4 the new word vector is YS , where YS is computed from the diagonal matrix S
5 and the extension matrix Y ; and
6 the word vector transformation matrix is K , wherein K is obtained from a
7 Choleski decomposition of a matrix derived from the extension matrix Z .

1 29. The apparatus of claim 26, wherein the LSA space adapter transforms the LSA
2 space by applying the document vector transformation matrix and the word vector
3 transformation matrix simultaneously.

1 30. The apparatus of claim 26, wherein when the new document matrix contains more
2 new documents than new words, then the LSA space adapter transforms space by:
3 applying the word vector transformation matrix K , first; and
4 applying the document vector transformation matrix is J second, wherein the
5 extension matrix Y is not obtained by folding in the new word-document matrix, but is
6 rather derived from the extension matrix Z .

1 31. The apparatus of claim 26, wherein when the new document matrix contains more
2 new words than new documents, then the LSA space adapter transforms the LSA space
3 by:
4 applying the document vector transformation matrix J first; and

5 applying the word vector transformation matrix K second, wherein the extension
6 matrix Z is not obtained by folding in the new word-document matrix, but is rather
7 derived from the extension matrix Y .

1 32. The apparatus of claim 23, wherein the change in the language is a change in the
2 language's domain.

1 33. The apparatus of claim 23, wherein the change in the language is a change in the
2 language's style.

1 34. An apparatus for recognizing speech, the apparatus comprising:
2 means for recognizing an audio input as a new document; and
3 means for processing the new document using latent semantic adaptation; and
4 means, coupled to the means for processing, for semantically inferring from a
5 vector representation of the new document which of a plurality of known words and
6 known documents correlate to the new document.

1 35. The apparatus of claim 34, wherein the means for processing the sequence of
2 words and documents using latent semantic adaptation comprises:
3 means for generating a latent semantic analysis (LSA) space from a training
4 corpus of documents representative of a language;

5 means for receiving the new document that represents a change in the language;

6 and

7 means for adapting the LSA space to reflect the change in the language.

1 36. The apparatus of claim 34, wherein the means for adapting the LSA space to
2 reflect the change in the language comprises a means for transforming the LSA space to
3 take into account the new document's influence on the LSA space without re-computing
4 the LSA space.

1 37. The apparatus of claim 34, wherein the means for transforming the LSA space
2 comprises:

3 means for obtaining a training document vector that characterizes a semantic
4 position of the training document within the LSA space;

5 means for computing a new document vector that characterizes a semantic
6 position of the new document within the LSA space;
7 means for deriving a document vector transformation matrix; and
8 means for applying the document vector transformation matrix to the training
9 document vector and the new document vector to shift a position of each document vector
10 in the LSA space, where the shift in the position reflects the change in the language.

1 38. The apparatus of claim 37, wherein the means for transforming the LSA space
2 further comprises:

3 means for obtaining a training word vector that characterizes a semantic position
4 of the training word within the LSA space;
5 means for computing a new word vector that characterizes a semantic position of
6 the new word within the LSA space;
7 means for deriving a word vector transformation matrix; and
8 means for applying the word vector transformation matrix to the training word
9 vector and the new word vector to shift a position of each word vector in the LSA space,
10 where the shift in the position reflects the change in the language.

1 39. The apparatus of claim 38, wherein:
2 the training document vector is VS , where VS is computed from a right singular
3 matrix V and a diagonal matrix S , each of which was obtained from a previous singular
4 value decomposition (SVD) of a training word-document matrix constructed during the
5 generation of the LSA space, the training word-document matrix representing the extent
6 to which each of the words appears in each of the documents of the training corpus;
7 the new document vector ZS , where ZS is computed from the diagonal matrix
8 S and an extension matrix Z , wherein Z is an extension of the right singular matrix
9 V obtained by folding in a new word-document matrix, the new word-document matrix
10 representing the extent to which a new word appears in the new document; and
11 the document vector transformation matrix is J , wherein J is obtained from a
12 Choleski decomposition of a matrix derived from an extension matrix Y , wherein Y is an
13 extension of a left singular matrix U obtained by folding in the new word-document

14 matrix, and wherein U was obtained from the previous SVD of the training word-
15 document matrix constructed during the generation of the LSA space.

1 40. The apparatus of claim 39, wherein:

2 the training word vector is US , wherein US is computed from the left singular
3 matrix U and the diagonal matrix S ;

4 the new word vector is YS , where YS is computed from the the diagonal matrix
5 S and the extension matrix Y ; and

6 the word vector transformation matrix is K , wherein K is obtained from a
7 Choleski decomposition of a matrix derived from the extension matrix Z .

1 41. The apparatus of claim 37, wherein the means for transforming the LSA space
2 further comprises means for applying the document vector transformation matrix and the
3 word vector transformation matrix simultaneously.

1 42. The apparatus of claim 37, wherein when the new document matrix contains more
2 new documents than new words, then the means for transforming the LSA space further
3 comprises:

4 means for applying the word vector transformation matrix K , first; and
5 means for applying the document vector transformation matrix J second, wherein
6 the means for obtaining the extension matrix Y is not by folding in the new word-

7 document matrix, but is rather by deriving extension matrix Y from the extension matrix
8 Z .

1 43. The apparatus of claim 37, wherein when the new document matrix contains more
2 new words than new documents, then the means for transforming the LSA space further
3 comprises:

4 means for applying the document vector transformation matrix J first; and
5 means for applying the word vector transformation matrix K second, wherein the
6 means for obtaining the extension matrix Z is not by folding in the new word-document
7 matrix, but is rather by deriving the extension matrix Z from the extension matrix Y .

1 44. The apparatus of claim 35, wherein the change in the language is a change in the
2 language's domain.

1 45. The apparatus of claim 35, wherein the change in the language is a change in the
2 language's style.

1 46. An system for processing speech, the system comprising:
2 a speech recognition database comprising a latent semantic analysis (LSA) space
3 generated from a training corpus of documents representative of a language;
4 an input receiver to receive a new document that represents a change in the
5 language; and

6 a processing system to adapt the LSA space to reflect the change in the language.

1 47. The system of claim 46, wherein the processing system adapts the LSA space by
2 transforming the LSA space to take into account the new document's influence on the
3 LSA space without re-computing the LSA space.

1 48. The system of claim 46, wherein the processing system transforms the LSA space
2 by:

3 obtaining a training document vector that characterizes a semantic position of the
4 training document within the LSA space;

5 computing a new document vector that characterizes a semantic position of the
6 new document within the LSA space;

7 deriving a document vector transformation matrix; and

8 applying the document vector transformation matrix to the training document
9 vector and the new document vector to shift a position of each document vector in the
10 LSA space, where the shift in the position reflects the change in the language.

1 49. The system of claim 48, wherein the processing system further transforms the
2 LSA space by:

3 obtaining a training word vector that characterizes a semantic position of the
4 training word within the LSA space;

5 computing a new word vector that characterizes a semantic position of the new
6 word within the LSA space;

7 deriving a word vector transformation matrix; and
8 applying the word vector transformation matrix to the training word vector and
9 the new word vector to shift a position of each word vector in the LSA space, where the
10 shift in the position reflects the change in the language.

1 50. The system of claim 49, wherein:
2 the training document vector is VS , where VS is computed from a right singular
3 matrix V and a diagonal matrix S , each of which was obtained from a previous singular
4 value decomposition (SVD) of a training word-document matrix constructed during the
5 generation of the LSA space, the training word-document matrix representing the extent
6 to which each of the words appears in each of the documents of the training corpus;
7 the new document vector ZS , where ZS is computed from the diagonal matrix S
8 and an extension matrix Z , wherein Z is an extension of the right singular matrix
9 V obtained by folding in a new word-document matrix, the new word-document matrix
10 representing the extent to which a new word appears in the new document; and
11 the document vector transformation matrix is J , wherein J is obtained from a
12 Choleski decomposition of a matrix derived from an extension matrix Y , wherein Y is an
13 extension of a left singular matrix U obtained by folding in the new word-document
14 matrix, and wherein U was obtained from the previous SVD of the training word-
15 document matrix constructed during the generation of the LSA space.

1 51. The system of claim 50, wherein:

2 the training word vector is US , where US is computed from a left singular matrix
3 U and the diagonal matrix S ;
4 the new word vector is YS , wherein YS is computed from the diagonal matrix S
5 and the extension matrix Y ; and
6 the word vector transformation matrix is K , wherein K is obtained from a
7 Choleski decomposition of a matrix derived from the extension matrix Z .

1 52. The system of claim 50, wherein the processing system transforms the LSA space
2 by applying the document vector transformation matrix and the word vector
3 transformation matrix simultaneously.

1 53. The system of claim 50, wherein when the new document matrix contains more
2 new documents than new words, then the processing system transforms space by:
3 applying the word vector transformation matrix K , first; and
4 applying the document vector transformation matrix is J second, wherein the
5 extension matrix Y is not obtained by folding in the new word-document matrix, but is
6 rather derived from the extension matrix Z .

1 54. The system of claim 50, wherein when the new document matrix contains more
2 new words than new documents, then the processing system transforms the LSA space
3 by:
4 applying the document vector transformation matrix J first; and

5 applying the word vector transformation matrix K second, wherein the extension
6 matrix Z is not obtained by folding in the new word-document matrix, but is rather
7 derived from the extension matrix Y .

1 55. The system of claim 46, wherein the change in the language is a change in the
2 language's domain.

1 56. The system of claim 46, wherein the change in the language is a change in the
2 language's style.

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